

# Algal Biotechnology

## Background

It has been known that Spirulina has significantly potential as sources of protein and high-value chemicals such as essential fatty acids, e.g. linoleic acid and g-linolenic acid (GLA), including the photosynthetic pigments e.g. chlorophyll a and phycocyanin. Currently, Spirulina has more widely markets for health food, animal food, cosmetics and pharmaceutical product.

The Algal Biotechnology research group at KMUTT has started an interest in Spirulina around 1987 since the discovery of Spirulina growing profusely in a stabilization pond of tapioca starch wastewater and Thailand climate is suited in large scale for Spirulina cultivation. With financial support from the National Center for Genetic Engineering and Biotechnology (BIOTEC), the research begun from the use of tapioca starch wastewater as (a) substrate for cultivation in order to reduce production costs. Since then the research group has focused on developments of mass cultivation techniques to obtain high productivity, extraction processes of lipid/phycoyanin in pilot scale, and also understanding the physiological factors influenced biomass and high value chemicals, and molecular biology.

Spirulina consortium was set up in 2002 by BIOTEC, Nation Science and Technology Development Agency (NSTDA) and Algal Biotechnology Laboratory, King Mongkut's University of Technology Thonburi. The purpose of Spirulina consortium is to bring together the private sectors who involve in cultivation, trading and the research in order to help strengthen the private sectors.

## Goals and Objectives

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To develop technologies needed for microalgal cultivation and also develop suitable strains for commercial purpose.

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To understand the biosynthesis of high value chemicals from Spirulina.

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To use Spirulina as a plant model for the study of stress response, photosynthesis and respiration.

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To promote university-industry linkage in algal biotechnology.

## Current R&D

### 1. Mass cultivation of Spirulina and microalgae

- Obtain the maximum benefit from the product by manipulation of culture conditions
- Study the physiological factors stimulating biomass and high value chemical production and develop the mathematic model to predict the interest products.
- Obtain the suitable strains for outdoor cultivation according to the photosynthetic characteristics
- Develop the mathematic model to predict biomass

## 2. High value chemicals

- Study on stress response
- Extraction of lipid and phycocyanin in pilot scale techniques

## 3. Molecular biology

- Mechanism of the desaturase enzyme and phycocyanin
- Proteomic
- Genomic
- Transformation

## Technology Transfer

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Outdoor mass cultivation of Spirulina at commercial scale

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High value chemical production/extraction from Spirulina

## Products and Services

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Consulting

With a strong background and research experience in algal technology, our group is in a unique position to offer consulting and knowledge transfer to private organizations. The scope of consulting ranges from mass cultivation techniques and lipid/phycoerythrin extraction processes to the design of reactors.

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Training Courses

Training courses in the field of algal technology are regularly offered to both the academic and private sectors. Top researchers in the field from overseas are often invited as guest speakers in these courses. The topics most commonly covered are physiology and biotechnology especially for mass cultivation of microalgae and uses of Spirulina biomass and its high valued chemicals.

## Publications

National Journal

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Kunsuk, J., Ruengjitchawalaya, M., Chaiklahan, R., Hongthong, A., Bunnag, B. and Tanticharoen, M. 2004 "Effect of berberine on fatty acid composition in plasma and thylakoid membrane in Spirulina sp. Journal of Scientific Research

Chulalongkorn University (Section T), 1, 279-286.

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 Chaiklahan, R., Khonsarn, N., Chirasuwan, N., Ruengjitchatchawalya, M. Bunnag, B. and Tanticharoen, M. 2007 &ldquo;Response of *Spirulina platensis* C1 to High Temperature and High Light Intensity&rdquo; *Kasetsart J. (Nat. Sci.)* 41 (1):123-129.

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 Prommeenate, P., Kurdrut, P. Sirijuntarut, M. and Hongsthong, A. 2007 &ldquo;Expression of Fatty Acid Desaturase Enzymes from Cyanobacterium *Spirulina platensis* in Yeast *Saccharomyces cerevisiae*&rdquo; *Kasetsart J. (Nat. Sci.)* 41 (1):130-135.

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 Chirasuwan, N., Chaiklahan, R., Ruengjitchatchawalya, M., B. Bunnag and Tanticharoen, M. 2005 &ldquo;Anti HSV-1 Activity of *Spirulina platensis* Polysaccharide&rdquo; *Kasetsart J. (Nat. Sci.)* 41(2): 311-318.

#### International Journal

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 Subudhi, S., Kurdrut, P., Hongsthong, A., Sirijuntarut, M., Cheevadhanarak, S. and Tanticharoen, M. 2008 &ldquo;Isolation and functional characterization of *Spirulina* D6D gene promoter: Role of a putative GntR transcription factor in transcriptional regulation of D6D gene expression&rdquo; *Biochemical and Biophysical Research Communications* 365: 643-649.

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 Wattana Jeamton, W., Mungpakdee, S., Sirijuntarut, M., Prommeenate, P., Cheevadhanarak, S., Tanticharoen, M. and Hongsthong, A. 2008 &ldquo;A combined stress response analysis of *Spirulina platensis* in terms of global differentially expressed proteins, and mRNA levels and stability of fatty acid biosynthesis genes&rdquo; *FEMS Microbiology Letters* 281(2), 121&ndash;131.

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 Hongsthong, A., Sirijuntarut, M., Prommeenate, P., Thammathorn, S., Bunnag, B., Cheevadhanarak, S. and Tanticharoen, M. 2007 &ldquo;Revealing differentially expressed proteins in two morphological forms of *Spirulina platensis* by proteomic analysis&rdquo; *Molecular Biotechnology* 36:123-130.

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 Kurdrut, P., Subudhi, S., Cheevadhanarak, S., Tanticharoen, M. and Hongsthong, A. 2007 &ldquo;Effect of two intermediate electron donors, NADPH and FADH<sub>2</sub>, on *Spirulina*  $\Delta$ 6-desaturase co-expressed with two different immediate electron donors, cytochrome b5 and ferredoxin, in *Escherichia coli*&rdquo; *Mol. Biol. Rep.* 34: 261-266.

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Hongsthong A., Subudhi, S., Sirijuntarut, M., Kurdrin, P. and Cheevadhanarak, S. 2006. Revealing the complementation of ferredoxin by cytochrome b5 in Spirulina-D6-desaturation reaction by N-terminal fusion and coexpression of fungal-cytochrome b5 domain and Spirulina-D6-acyl-lipid desaturase. *Appl. Microbiol. Biotechnol.* 72:1192-1201.

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Kurdrin, P., Subudhi, S., Hongsthong, A., Ruengjitchatchawalya, M. and Tanticharoen, M. 2005 &ldquo;Functional expression of Spirulina -D6-desaturase gene in Yeast *Saccharomyces cerevisiae*&rdquo; *Mol. Biol. Reports*, 32(4):215-226.

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Ruengjitchatchawalya, M., Kovács, L., Mapaisansup, T., Sallai, A., Gombos, Z., Ponglikitmongkol, M. and Tanticharoen, M. 2005 &ldquo;Higher plant-like fluorescence induction and thermoluminescence characteristics in cyanobacterium, *Spirulina* mutant defective in PQH2 oxidation by cytb6/f complex&rdquo; *Journal of Plant Physiology*, 162: 1123-1132.

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Hongsthong, A., Subudhi, S., Sirijuntarat, M. and Cheevadhanarak, S. 2004 &ldquo;Mutation study of conserved amino acid residues of Spirulina D6-acyl-lipid desaturase showing involvement of histidine 313 in the regioselectivity of the enzyme. *App. Microbiol. Biotechnol.*66: 74-84.

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Hongsthong, A., Deshniem, P., Paithoonrangsarid, K., Cheevadhanarak, S. and Tanticharoen, M. 2003. &ldquo;Differential Responses of Three Acyl-Lipid Desaturases to Immediate Temperature Reduction Occurring in Two Lipid Membranes of *Spirulina platensis* Strain C1&rdquo; *J. Biosci. Bioeng.* 96(6), 519-524.

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Hongsthong, A., Deshniem, P., Paithoonrangsarid, K., Phapugrangkul, P., Tanticharoen, M. and Cheevadhanarak, S. &ldquo;Effect of temperature on the desaturase genes translation in *Spirulina platensis* C1.&rdquo; *Journal of Applied Phycology*. . (Proceeding)

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Ruengjitchatchawalya, M., Chirasuwan, N., Chaiklahan, R., Bunnag, B., Deshniem, P. and Tanticharoen, M. 2002. &ldquo;Photosynthetic characteristics of a mutant of *Spirulina plantensis*.&rdquo; *Journal of Applied Phycology*. 14: 71-76.

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Deshniem, P., Paitoonrangsarit, K., Suphatrakul, A., Meesapyodsuk, D., Tanticharoen, M. and Cheevadhanarak, S. 2000 "Temperature-independent and dependent expression of desaturase genes in filamentous cyanobacterium *Spirulina platensis* C1 (*Arthrospira* sp. PCC9438)." *FEMS Micro. Lett.* 184:207-213.

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Tanticharoen, M., Bunnag, B. and Vonshak, A. 1993 "Cultivation of *Spirulina* using Secondary treated starch wastewater" *Australasian Biotechnology*. 3:223-226.

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